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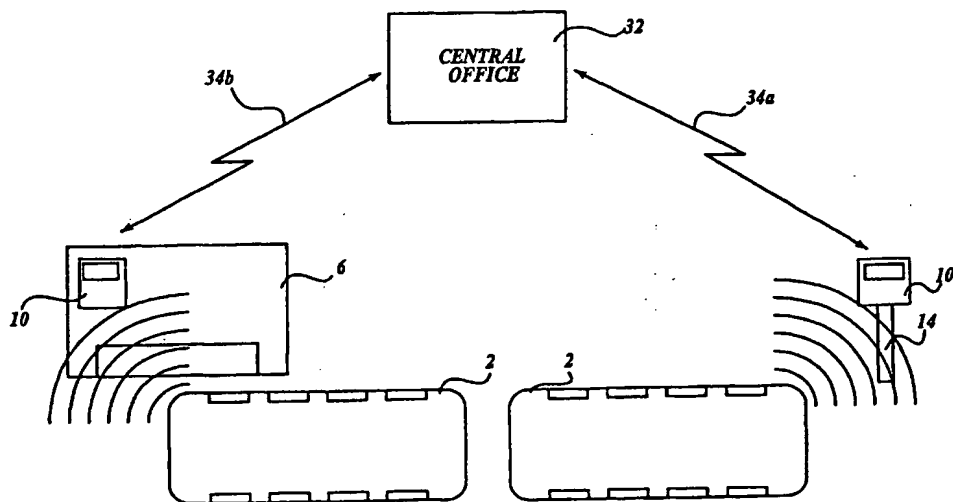
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(54) Title: METHOD AND SYSTEM FOR PROVIDING AN ESTIMATED TIME OF ARRIVAL FOR A BUS

(57) Abstract

A method and system for providing an estimated time of arrival ("ETA") for a bus. A bus stop device is installed at each bus stop. The bus stop includes an intelligent transponder/receiver, a transmitter/receiver, and a display. The bus stop devices may also comprise a solar cell for powering the bus stop device, and may also include a temperature control unit for controlling the temperature of the bus stop device. The intelligent transponder/receiver can detect a bus proximate to the bus stop device by receiving the transmission

of a unique bus identification code transmitted by a bus device installed on a bus. When the bus stop device receives such a transmission, the bus stop device can compare the actual arrival time of the bus to an expected time of arrival for the bus. If the actual time of arrival exceeds the expected time of arrival by a preset threshold amount, the bus stop device may utilize the transmitter/receiver to transmit a notification message to a central office or, the bus device may transmit the notification message to the central office. The transmission of the notification message may be made over an existing cellular network or through an existing communications satellite. The central office receives the notification message and, in response, calculates the ETA of the bus at one or more downstream bus stop devices located downstream on the bus route from the transmitting bus stop device. The central office then transmits the ETA for the bus to each of the downstream bus stop devices. The downstream devices then utilize the built-in display to display the ETA for the bus.



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## METHOD AND SYSTEM FOR PROVIDING AN ESTIMATED TIME OF ARRIVAL FOR A BUS

### Cross-Reference to Related Applications

5        This application claims the benefit of U.S. Provisional Application No. 60/129,857, filed April 17, 1999, and U.S. Provisional Application No. 60/132,942, filed May 6, 1999.

### Field of the Invention

10       This invention generally relates to the field of transportation systems and, more specifically, relates to a method and system for determining and providing an estimated time of arrival for a bus.

### Background of the Invention

15       Riding a public bus is often a less than pleasurable experience for passengers for many reasons. One of the factors that contributes most significantly to the negative experience for most passengers is the lack of information regarding the time of arrival for a particular bus. While printed bus schedules are made widely available to passengers, buses frequently deviate from the printed schedule. Buses may be delayed due to a wide variety of reasons including poor weather, traffic congestion or accidents, mechanical problems with the bus, or even personnel problems with the driver or other transportation system staff. Delays such as these can be very frustrating for passengers, especially if they are trying to make an appointment at a specific time or trying to get to work on time. Moreover, bus delays can be especially frustrating for passengers that may be forced to wait at an unsheltered bus stop in the rain or in cold weather. Without reliable information regarding the  
25       estimated time of arrival ("ETA") for a bus, passengers may be unable to make

stop in the rain or in cold weather. Without reliable information regarding the estimated time of arrival ("ETA") for a bus, passengers may be unable to make informed decisions regarding whether to continue to wait for the bus or to seek an alternative method of transportation.

5        Systems do exist for providing an ETA for a bus. However, these systems suffer from a number of serious drawbacks which make them difficult and expensive to operate. One of the biggest drawbacks of existing bus ETA systems is their inefficient transmission of the data necessary to determine the ETA for a bus. These systems typically transmit data continuously from a bus to a central office and then  
10       back to a bus stop device. A large amount of expensive wireless bandwidth is necessary in order to continuously transmit this data. Previous bus ETA systems are therefore very expensive to operate due to the continuous transmission of data.

Another serious drawback of previous bus ETA systems is their use of proprietary communications links for the transmission of data. Previous systems  
15       typically utilize proprietary long-range radios that may require the installation of special transmitters and receivers throughout the service area. These systems can be complicated and costly to install and maintain. Other problems with previous bus ETA systems include difficulty in providing power to remotely located bus stop devices and difficulty in controlling the operating temperature of bus stop devices  
20       located in very hot or very cold areas.

In light of these problems, there is a need for a method and system for providing an ETA for a bus that can provide passengers with a real-time status report indicating when the bus will actually arrive at a bus stop. There is a further need for a method and system for providing an ETA for a bus that minimizes the amount of  
25       transmitted data required to provide an ETA for a bus. There is an additional need for a method and system for providing an ETA for a bus that advantageously utilizes an existing data transmission infrastructure to transmit the data necessary to provide the ETA for a bus.

### 30       Summary of the Invention

The present invention solves the above-described problems by providing a method and system for providing an ETA for a bus. In particular, the present invention advantageously provides a real-time ETA for a bus at a bus stop. Moreover, the present invention advantageously minimizes the amount of transmitted  
35       data necessary to provide the ETA for a bus. Additionally, the present invention can advantageously utilize a relatively low-cost existing data transmission infrastructure,

such as a cellular network, to transmit all of the data necessary to provide an ETA for a bus.

Generally described, the present invention provides a method and system for providing an ETA for a bus at a bus stop or other location. A bus stop device is utilized at a bus stop that is capable of detecting a passing bus equipped with a bus device. When a bus is detected at the bus stop device, the current time is compared to an expected time of arrival for the bus. If the difference between the current time and the expected time of arrival exceeds a preset threshold, such as 10 minutes, an ETA for the bus at a downstream bus stop is calculated. The ETA for the bus at the downstream bus stop is then transmitted to a bus stop device located at the downstream bus stop. The downstream bus stop then displays the ETA for the bus. By only transmitting the ETA for a bus when the delay in the bus schedule exceeds a preset threshold, the amount of data transmitted is reduced and valuable bandwidth is conserved.

More specifically described, according to one actual embodiment of the invention, a bus stop device is installed at a bus stop. The bus stop includes an intelligent transponder/receiver, a transmitter/receiver, and a display. The bus stop devices may also comprise a solar cell for powering the bus stop device, and may also include a temperature control unit for controlling the temperature of the bus stop device. The intelligent transponder/receiver can detect a bus proximate to the bus stop device by receiving the transmission of a unique bus identification code transmitted by a bus device installed on a bus. When the bus stop device receives such a transmission, the bus stop device can compare the actual arrival time of the bus to an expected time of arrival for the bus. If the actual time of arrival exceeds the expected time of arrival by a preset threshold amount, the bus stop device may utilize the transmitter/receiver to transmit a notification message to a central office. Alternatively, the bus device may transmit the notification message to the central office. The transmission of the notification message may be made over an existing cellular network or through an existing communications satellite.

The central office receives the notification message and, in response, calculates the ETA of the bus at one or more downstream bus stop devices located downstream on the bus route from the transmitting bus stop device. The central office then transmits the ETA for the bus to each of the downstream bus stop devices. The downstream devices then utilize the built-in display to show the ETA for the bus. In this manner, ETA information is only transmitted to downstream bus stop devices

for buses that have actual arrival times that differ from the expected arrival times more than the threshold amount.

In accordance with another aspect of the present invention, a bus may be equipped with an apparatus for determining the geographical location of the bus, such as a Global Positioning System ("GPS") receiver. The bus may periodically determine its location utilizing information received from GPS satellites. The bus may then utilize an on-board transmitter/receiver to transmit the location to a central office. The location may be transmitted over a cellular network or via a communications satellite.

The central office receives the location of the bus and, using route and schedule information for the bus maintained at the central office, calculates the difference between the actual time the bus arrived at the location and the expected arrival time for the bus at the location. The central office then determines whether the actual and expected arrival times vary more than a preset threshold amount. If the actual and expected arrival times differ more than the preset threshold amount, the central office calculates an ETA for the bus at bus stops located downstream from the bus on the bus route. The central office then transmits the ETA information to bus stop devices located at the downstream bus stops. The bus stop devices then display the ETA for the bus. The central office may utilize a cellular network or a communications satellite to transmit the ETA to the downstream bus stop devices.

In accordance with yet another aspect of the present invention, the bus device can store the route and schedule for the bus. When the bus passes a bus stop, the bus device transmits the schedule to the bus stop device located at the stop. In this manner, the bus stop device is programmed with the bus schedule. The bus stop device responds with a transmission of the bus stop number to the bus device. In response to receiving the bus stop number, the bus device determines the difference between the actual arrival time at the bus stop and the expected arrival time as set forth in the schedule. If the difference between the actual arrival time and the expected arrival time exceeds a preset threshold amount, the bus stop device transmits a notification message to a central office. A standard cellular network or communications satellite may be utilized to transmit the notification message.

The central office receives the notification message and, in response, calculates the ETA of the bus at bus stops on the bus route that are downstream from the current location of the bus. The central office then transmits the ETA of the bus at the downstream bus stops to bus stop devices located at the downstream bus stops. The bus stop devices then decode the data and display the ETA for the bus. The bus

stop devices may also decode and display weather information, advertisements, or other types of information. The bus stop devices may include a solar panel for providing power to the bus stop device, and may include a temperature control unit for maintaining the temperature of the bus stop device.

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#### Brief Description of the Drawings

The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated as the same becomes better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

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FIGURE 1 is a block diagram illustrating an actual operating environment for aspects of the present invention.

FIGURE 2 is a block diagram showing the operation of an actual embodiment of the present invention.

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FIGURE 3A is a block diagram showing an illustrative bus stop and bus stop device utilized in an actual embodiment of the present invention.

FIGURE 3B is a block diagram showing an illustrative pole with an attached bus stop device utilized in an actual embodiment of the present invention.

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FIGURE 3C is a block diagram showing a hardware architecture for a bus stop device utilized in an actual embodiment of the present invention.

FIGURES 3D and 3E are block diagrams illustrating a display unit utilized in a bus stop device in an illustrative embodiment of the present invention.

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FIGURE 4 is a block diagram showing a hardware architecture for a storage/transmitter unit utilized in a bus in an actual embodiment of the present invention.

FIGURE 5 is a block diagram illustrating the communication paths between a bus, a bus stop device, and a central office in an actual embodiment of the present invention.

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FIGURE 6A is a state diagram illustrating the operation of a bus device in accordance with an actual embodiment of the present invention.

FIGURE 6B is a state diagram illustrating the operation of a bus stop device in accordance with an actual embodiment of the present invention.

FIGURE 6C is a state diagram illustrating the operation of a central office in accordance with an actual embodiment of the present invention.

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FIGURE 7 is a state diagram illustrating the operation of a bus stop device in accordance with an actual embodiment of the present invention.

FIGURE 8 is a block diagram showing the operation of an actual embodiment of the present invention that utilizes GPS satellites to track the location of a bus.

FIGURE 9 is a block diagram showing the operation of an actual embodiment of the present invention that utilizes cellular or satellite transmissions to relay the location of a bus to a central office.

FIGURE 10 is a block diagram showing an illustrative hardware architecture for receiving location information from GPS satellites and transmitting the location information to a central office.

FIGURE 11 is a block diagram showing a hardware architecture for a bus stop device utilized in an actual embodiment of the present invention.

FIGURE 12A is a state diagram illustrating the operation of a bus device in accordance with an actual embodiment of the present invention.

FIGURE 12B is a state diagram illustrating the operation of a bus stop device in accordance with an actual embodiment of the present invention.

FIGURE 12C is a state diagram illustrating the operation of a central office in accordance with an actual embodiment of the present invention.

FIGURE 13 is a state diagram illustrating the operation of a bus device in accordance with an actual embodiment of the present invention.

FIGURE 14A is a state diagram illustrating the operation of a bus device in accordance with an actual embodiment of the present invention.

FIGURE 14B is a state diagram illustrating the operation of a bus stop device in accordance with an actual embodiment of the present invention.

FIGURE 14C is a state diagram illustrating the operation of a central office in accordance with an actual embodiment of the present invention.

#### Detailed Description of the Preferred Embodiment

As will be better understood from the following description, the present invention provides a method and system for providing an ETA for a bus. Referring now to the figures, in which like numerals represent like elements, aspects of the present invention will be described. As shown in FIGURE 1, a bus 2 travels along a bus route 4 through a city. The bus route 4 takes the bus 2 down Pacific Avenue past 7<sup>th</sup> Avenue and 9<sup>th</sup> Avenue. The bus route 4 then takes the bus 2 down 5<sup>th</sup> Avenue and then down South Commerce Street.

Bus stops 6A-6N are located periodically along the bus route 4 at locations that are convenient for bus passengers. Bus stop 6A and bus stop 6B are located on Pacific Avenue, and bus stop 6N is located on South Commerce Street. As will be

described in more detail below, communication takes place between the bus 2, a bus stop device (not shown in FIGURE 1), and a central office (not shown in FIGURE 1), that allows the ETA of the bus at bus stops downstream from the location of the bus to be calculated. The ETA of the bus 2 is then displayed on the downstream bus stop devices. For instance, if the bus 2 is travelling proximate to the bus stop 6A, the ETA for the bus 2 at bus stops 6B-6N will be computed and displayed at the bus stops 6B-6N. In this manner, passengers waiting at these bus stops may be apprised of the ETA of the bus.

As shown in FIGURE 2, each bus stop 6 is traditionally equipped with a bench 8 for passengers to sit on. Additionally, each bus stop 6 is also equipped with a bus stop device 10. As will be described in more detail below, signals 12 and 13 are transmitted between the bus 2 and the bus stop device 10 as the bus 2 travels proximate to the bus stop device 10. According to an actual embodiment of the invention, a signal 12 is transmitted from the bus 2 to the bus stop device 10 that informs the bus stop device 10 that the bus has arrived. According to another actual embodiment of the present invention, the bus 2 transmits a signal 12 to the bus stop device 10 that includes a bus identification number and a schedule for the bus. The bus stop device 10 responds to the transmission by transmitting the bus stop number back to the bus 2. Details regarding these communications are described in greater detail below.

As shown in FIGURE 3A, a bus stop device 10 may be located in a traditional covered bus stop 6 or, as shown in FIGURE 3B, the bus stop device 10 may be mounted on a pole 14. According to an actual embodiment of the present invention, a bus stop device 10 is located at each bus stop. As shown in FIGURE 3C, each bus stop device 10 includes an intelligent transponder/receiver 16 for communicating with buses as they pass proximately to the bus stop device. A bus stop device 10 also includes a transmitter/receiver 18 for communicating with a central office 32 (not shown in FIGURE 3C). A bus stop device 10 may also include a solar cell 22 and a battery (not shown) for providing power to the bus stop device 10, and may additionally include a temperature control unit 19 for controlling the operating temperature of the bus stop device 10. Devices similar to the bus stop device 10 but without a display may be located between bus stops that are far apart.

A bus stop device 10 also includes a display 20 for displaying the ETA for a bus 2. As shown in FIGURE 3D, the display 20 may include information such as the bus route number, and an ETA for the bus. As illustrated in FIGURE 3D, bus number 123 is estimated to arrive at the bus stop in 12 minutes. Likewise, bus

number 136 is estimated to arrive at the bus stop in three minutes. As shown in FIGURE 3E, the display 20 may also be utilized in an embodiment of the present invention to display weather information. For instance, as illustrated in FIGURE 3E, route number 123 has been closed due to snow but route number 136 is open. Those skilled in the art should appreciate that the display 20 may also be utilized to provide advertising or other information to passengers waiting at a bus stop.

A bus 2 operating within a system provided by an embodiment of the present invention is equipped with a storage/transmitter unit 24, also called a bus device, as shown in FIGURE 4. In an embodiment of the present invention, the storage/transmitter unit 24 transmits information to the intelligent transponder/receiver 16 located at a bus stop 6 via one or more antennae 30 when the bus 2 passes proximate to the bus stop 6. In particular, the bus 2 transmits a bus identification code, that is unique to the bus 2, to the bus stop device 10. The data storage element 28 is utilized to store the bus identification code and other information, and the radio frequency transmitter 26 is utilized to transmit the bus identification code to the bus stop device 10. The bus device 24 may transmit the bus identification code in response to detecting a transmission from the bus stop device 10, or it may continuously transmit the bus identification code. A suitable storage/transmitter unit 24 is a device such as the Micron Interrogator as known to those skilled in the art. Those skilled in the art should appreciate that other forms of short-range wireless data transmission, such as infrared data transmission, could be utilized to transmit the bus identification code from the bus 2 to the bus stop device 10.

The bus 2 may transmit the bus identification code to a bus stop device 10 located at a covered bus stop 6 bus stop device or mounted on a pole 14 as shown in FIGURE 5. The bus identification code is received by the bus stop device 10 and transmitted to a central office 32. The transmission 34a-34b between the bus stop device 10 and the central office 32 may take place over a standard cellular network as known to those skilled in the art. Other suitable forms of two-way wireless communication as known to those skilled in the art may also be utilized in place of the cellular network.

According to an embodiment of the present invention, the central office 32 calculates the ETA of the bus 2 at bus stops 6 on the bus route 4 located downstream from the bus 2. The central office 32 then transmits the ETA data to bus stop devices 10 located downstream from the location of the bus. The transmission from the central office 32 to each bus stop device 10 also takes place over a cellular

network or similar two-way communications link. Each bus stop device 10 receives the ETA information from the central office 32 and displays the ETA on the display 20. In this manner, downstream displays are updated each time a bus 2 arrives at a bus stop 6. As described above, weather, advertising, or other information  
5 may also be provided on the display 20.

According to another actual embodiment of the present invention, each bus stop device 10 may store expected bus arrival times. When the bus stop device 10 receives a bus identification code from a proximately located bus 2, the bus stop device 10 compares the actual bus arrival time with the expected bus arrival time.  
10 The bus stop device 10 then determines whether the difference between the actual arrival time and the expected arrival time exceeds a preset threshold, 30 minutes for instance. The bus stop device 10 only transmits the bus identification code to the central office 32 if the difference exceeds the preset threshold. In this manner, the central office 32 only transmits ETA information to downstream bus stops 6 for  
15 buses that have estimated arrival times that exceed the preset threshold. In this manner, expensive wireless data transmission bandwidth is conserved.

Referring now to FIGURE 6A, an illustrative state diagram 600 for the operation of a bus device 24 will be described. The bus device 24 begins operating in state 602. The bus device 24 waits in state 602 until a bus stop device 10 is  
20 detected. If a bus stop device 10 is detected, the bus device 24 enters state 604. In state 604, the bus device 24 transmits the bus identification code to the bus stop device 10. Once the bus device 24 has transmitted the bus identification code to the bus stop device 10, the bus device 24 returns to state 602. The bus device 24 may wait for an acknowledgement from the bus stop device 10 before returning to the  
25 waiting state 602. As described above, the bus device 24 may alternately transmit the bus identification code continuously.

Referring now to FIGURE 6B, an illustrative state diagram 625 for the operation of a bus stop device 10 will be described. The bus stop device 10 begins operation in state 626. In state 626, the bus stop device 10 displays the ETA for  
30 buses soon to be arriving at the bus stop. The ETA for these buses may be derived from expected arrival times stored at the bus stop device 10, or may be received from the central office 32. If a data packet is received from the central office, the bus stop device 10 enters state 630. At state 630, the bus stop device 10 decodes the data packet received from the central office 32 and updates the display with the ETA  
35 information contained in the data packet. In this manner, the bus stop device 10 always displays an updated ETA for each bus. The bus stop device 10 may also

decode weather, advertising, or other information contained in the data packet for display. Once the data packet has been decoded and the display updated, the bus stop device 10 returns to state 626 where the ETA and other information is displayed.

5 If the bus stop device 10 detects a proximately located bus 2 while at state 626, the bus device 10 enters state 628. At state 628, the bus stop device 10 receives the bus identification code from the bus 2. The bus stop device 10 may provide an acknowledgement to the bus 2 that the bus identification code has been received. The bus stop device 10 then transmits the bus identification code to the central office 32. The bus stop device 10 may also include the bus stop number and  
10 the time the bus identification code was received at the bus stop device 10 in the transmission. Once the transmission is completed, the bus stop device 10 returns to state 626.

Referring now to FIGURE 6C, an illustrative state diagram 650 for the operation of a central office 32 will be described. The central office 32 begins  
15 operating in state 652. The central office 32 waits in state 652 until a transmission, or timeliness report, is received from a bus stop device 10. If such a transmission is received, the central office 32 enters state 654. At state 654, the central office 32 computes the ETA of the bus 2 at bus stops 6 located downstream from the current location of the bus. To compute the ETA, the central office 32 may utilize the bus  
20 schedule, the distance between the current location of the bus and downstream bus stops, the average speed of the bus, and other data. Methods for determining the ETA of a vehicle at a location in this manner are well known to those skilled in the art. Once the ETA for the bus at downstream bus stops has been computed, the central office 32 transmits the ETA information to the downstream bus stops. The  
25 central office 32 then returns to waiting state 652. The central office 32 may also periodically enter state 656 where weather, advertisement, and other information is queued for transmission to bus stop devices 10. This information may then be transmitted by the central office 32 to the bus stop devices 10 at state 654.

Referring now to FIGURE 7, an alternative state diagram 700 for the  
30 operation of a bus stop device 10 will be described. The bus stop device 10 begins operation in state 702 where the bus stop device displays the ETA for buses soon to be arriving at the bus stop 6. As described above, the ETA for these buses may be derived from expected arrival times stored at the bus stop device 10, or may be received from the central office 32. If a data packet is received from the central  
35 office 32, the bus stop device 10 enters state 704 where the bus stop device decodes the data packet received from the central office and updates the display with the ETA

information contained in the data packet. In this manner, the bus stop device 10 always displays an updated ETA for each bus. The bus stop device 10 may also decode weather, advertising, or other information contained in the data packet for display. Once the data packet has been decoded and the display updated, the bus stop  
5 device 10 returns to state 702 where the ETA and other information is displayed.

If the bus stop device 10 detects a proximately located bus 2 while at state 702, the bus device 10 enters state 706, where the bus stop device receives the bus identification code from the bus. The bus stop device 10 may provide an acknowledgement to the bus 2 that the bus identification code has been received.  
10 From state 706, the bus stop device 10 enters state 708, where the bus stop device 10 compares the actual arrival time of the bus 2 to the expected arrival time stored at the bus stop device. The bus stop device 10 also determines whether the difference between the actual arrival time and the expected arrival time exceeds a preset threshold. If the difference does not exceed the preset threshold, the bus stop  
15 device 10 returns to state 702. If the difference exceeds the preset threshold, the bus stop device 10 enters state 710. At state 710, the bus stop device 10 transmits the bus identification code to the central office 32. The bus stop device 10 may also include the bus stop number and the time the bus identification code was received at the bus stop device in the transmission. Once the transmission is completed, the bus stop  
20 device 10 returns to state 710. In this manner, the central office 32 is only notified in the event a bus arrives at a bus stop later than the preset threshold amount.

Referring now to FIGURES 8 and 10, another actual embodiment of the present invention will be described. According to this embodiment of the present invention, a bus 2 is equipped with a bus device 24, also called a storage/transmitter  
25 unit 24, that comprises a radio frequency transmitter 26 and connected antennae 30, and a data storage element 28. Additionally, the storage/transmitter unit 24 comprises a global positioning system ("GPS") receiver 36. As known to those skilled in the art, a GPS receiver 36 can determine its geographical location by communicating with a plurality of GPS satellites 38A-38N. According to this  
30 embodiment of the invention, the GPS receiver 36 can determine the geographical location of the bus 2, and store the location in the data storage element 28. The radio frequency transmitter 26 may then be utilized to transmit the geographical location of the bus 2 to the central office 32. Information uniquely identifying the bus 2 such as a bus identification code may also be stored in the data storage element 28 and  
35 transmitted to the central office 32 with the bus location.

As shown in FIGURE 9, the bus location and the bus identification code may be transmitted from the bus 2 to the central office 32 via a cellular communications link 44 and a cellular station 40 as known to those skilled in the art. Likewise, this information may be transmitted from the bus 2 to the central office 32 via a satellite communications link 46 and a communications satellite 42 as known to those skilled in the art. Those skilled in the art should appreciate that other types of one-way communications links may be employed to transmit this information from the bus 2 to the central office 32.

According to this embodiment of the present invention, the central office 32 receives the bus location and bus identification code. The central office 32 then calculates the ETA of the bus 2 at bus stops 6 on the bus route located downstream from the bus 2. As known to those skilled in the art, the central office 32 may utilize the bus schedule, the distance between the current location of the bus and downstream bus stops, the average speed of the bus, and other data. Methods for determining the ETA of a vehicle at a location in this manner are well known to those skilled in the art. Once the central office 32 has determined the ETA, it transmits the ETA to bus stop devices 10 located downstream from the location of the bus via the one-way communications link 48. The transmission from the central office 32 to each bus stop device 10 may take place over a cellular network, satellite communications link, or other one-way communications link known to those skilled in the art. Each bus stop device 10 receives the ETA information from the central office 32 and displays the ETA on the display 20. In this manner, downstream displays may be continuously updated based upon the changing geographical location of the bus 2. As described above, weather, advertising, or other information may also be provided on the display 20.

According to another actual embodiment of the present invention, the central office 32 may store expected bus arrival times at different locations along the bus route. When the central office 32 receives a bus location and a bus identification code from a bus 2, the central office compares the bus location and time with the expected bus location at that time. The central office 32 then determines whether the difference between the actual location and the expected location at the specified time exceeds a preset threshold, 30 minutes for instance. The central office 32 only transmits the ETA information to the bus stop devices 10 if the difference exceeds the preset threshold. In this manner, the central office 32 only transmits ETA information to downstream bus stops 6 for buses that are behind schedule by more

than the preset threshold. In this manner, expensive wireless data transmission bandwidth is conserved.

As shown in FIGURE 11, the bus stop device 10 utilized in this embodiment of the present invention utilizes a receiver 50 to receive ETA data from the central office 32. The bus stop device 10 also comprises a solar panel 22 and battery (not shown) for providing power to the bus stop device 10 in areas where conventional power connections are unavailable. The bus stop device 10 also includes a display 20 for displaying bus ETA information, and a temperature control unit 19 for maintaining the internal operating temperature of the bus stop device 10.

Referring now to FIGURE 12A, an illustrative state diagram 1200 for the operation of a bus device 24 will be described. According to this embodiment of the present invention, the bus device 24 begins operation in state 1202 where signals from GPS satellites are received. Once a GPS signal has been received, the bus device 24 enters state 1204, where the current location of the bus device is determined based upon the signals received from the GPS satellites. Methods for determining the location of a GPS receiver based on signals received from GPS satellites are well known to those skilled in the art. Once the bus location has been determined, the bus device 24 enters state 1206 where the bus location is transmitted to the central office 32. Likewise, a unique bus identification code may also be transmitted to the central office 32. The bus device 24 then returns to state 1202 where signals are again received from the GPS satellites.

Referring now to FIGURE 12B, an illustrative state diagram 1225 for the operation of a bus stop device 10 will be described. According to this embodiment of the present invention, the bus stop device 10 begins operation in state 1226. In state 1226, the bus stop device 10 displays the ETA for buses soon to be arriving at the bus stop. The ETA for these buses may be derived from expected arrival times stored at the bus stop device 10, or may be received from the central office 32. If a data packet is received from the central office 32, the bus stop device 10 enters state 1228. At state 1228, the bus stop device 10 decodes the data packet received from the central office and updates the display with the ETA information contained in the data packet. In this manner, the bus stop device 10 always displays an updated ETA for each bus. The bus stop device 10 may also decode weather, advertising, or other information contained in the data packet for display. Once the data packet has been decoded and the display updated, the bus stop device 10 returns to state 1226 where the ETA and other information is displayed.

Referring now to FIGURE 12C, an illustrative state diagram 1250 for the operation of a central office 32 will be described. According to this embodiment of the present invention, the central office 32 begins operating in state 1252. The central office 32 waits in state 1252 until a bus location is received from a bus 2. If  
5 such a transmission is received, the central office 32 enters state 1254. At state 1254, the central office 32 computes the ETA of the bus at bus stops located downstream from the current location of the bus. As described above, the central office 32 may utilize the bus schedule, the distance between the current location of the bus and downstream bus stops, the average speed of the bus, and other data to compute the  
10 bus ETA. Once the ETA for the bus at downstream bus stops 6 has been computed, the central office 32 transmits the ETA information to the downstream bus stops. The central office 32 then returns to waiting state 1252. The central office 32 may also periodically enter state 1256 where weather, advertisement, and other information is queued for transmission to bus stop devices. This information may  
15 then be transmitted by the central office 32 to the bus stop devices 10 at state 1254.

Referring now to FIGURE 13, a state diagram 1300 describing the operation of a central office 32 according to another actual embodiment of the present invention will be described. The central office 32 begins operation at state 1302, where it receives a bus location and bus identification code from the bus 2. In  
20 response to receiving this information, the central office 32 enters state 1306, where the difference between the time the bus 2 arrived at the location and an expected time for the bus 2 to arrive at the location is calculated. A determination is also made by the central office 32 as to whether the difference exceeds a preset threshold. If the difference does not exceed the preset threshold, the central office 32 returns to  
25 state 1302. If the difference exceeds the preset threshold, the central office moves to state 1308, where the ETA of the bus 2 at bus stops 6 on the route that are downstream from the current location of the bus are calculated. As described above, the central office 32 may utilize the bus schedule, the distance between the current location of the bus and downstream bus stops, the average speed of the bus, and other  
30 data to compute the bus ETA at the downstream stops. The central office 32 then enters state 1304, where the ETA at the downstream bus stops 6 are transmitted to the downstream bus stop devices 10 for display. The central office 32 then returns to state 1302 where additional location information is received.

Referring now to FIGURE 14A, a state diagram 1400 for a bus device 24 will  
35 be described according to another actual embodiment of the present invention. According to this embodiment, neither the bus device 24 nor the bus stop device 10

initially stores schedule information for the bus. Rather, the schedule information is downloaded into the bus device 24 as the bus leaves a dispatch station. The schedule information is then transmitted from the bus device 24 to the bus stop device 10 as the bus 2 passes proximate to the bus stop device. Accordingly, the bus device 24  
5 begins operation at state 1402, where the bus 2 is waiting at the dispatch station. If the bus 2 leaves the dispatch station, the bus device 24 enters state 1404, where the bus schedule is received. The bus schedule may be transmitted to the bus device 24 using a short range wireless data transmission as known to those skilled in the art. The bus schedule may be stored in the data storage element 28 for future use. Once  
10 the bus device 24 has received the bus schedule, the bus device 24 returns to state 1402.

The bus device 24 enters state 1408 if a bus stop device 10 is detected by the bus device 24. As described above, the bus stop device 10 may transmit a short range signal to the bus device 24 identifying the bus stop device. In response to  
15 detecting the bus stop device 10, the bus device 24 transmits the bus schedule to the bus stop device. The bus stop device 10 may then display the schedule on its display. Also at state 1408, the bus stop device 10 determines whether it has arrived at the bus stop device in a timely fashion. The bus stop device 10 may perform this function by comparing an actual arrival time at the bus stop device to the expected arrival time  
20 set at the bus stop device set forth in the bus schedule. If the bus 2 has arrived at the bus stop device 10 in a timely fashion, the bus stop device returns to state 1402. If the bus 2 has arrived at the bus stop device 10 in an untimely fashion, the bus device 24 enters state 1410, where the bus device transmits an untimeliness report message to the central office 32 informing the central office of the untimely arrival.  
25 The message may include a bus identification code, the bus stop number at which the bus 2 has arrived, and a time of arrival at the bus stop. As described below with reference to FIGURE 14C, the central office 32 utilizes this information to calculate an ETA for the bus 2 at downstream bus stops 6. From state 1410, the bus device 24 returns to state 1402.

30 If the bus device 24 does not detect a bus stop device 10 within a specified period of time, the bus device may perform an inactivity timeout. When such a timeout occurs, the bus device 24 enters state 1406, where the bus stop device 10 determines its location using the GPS receiver. The bus stop device 10 also determines the timeliness of the bus using the bus schedule. If the bus 2 is  
35 proceeding in a timely manner, the bus device 24 returns to state 1402. If the bus 2 is

not proceeding in a timely manner, the bus device 24 enters state 1410, where an untimeliness report message is transmitted to the central office 32.

Turning now to FIGURE 14B, an alternative bus stop device 10 state diagram 1425 will be described. According to this embodiment of the present invention, the bus stop device 10 begins operation at state 1426, where the bus stop device displays the ETA for near future bus arrivals and other information. As described above, the ETA information may be utilized from the bus schedule received from a passing bus, or may be utilized from an ETA transmission received from the central office 32. If the bus stop device 10 detects a proximate bus, the bus stop device receives and stores the bus schedule. The bus stop device 10 may then display the ETA for timely buses according to the received schedule. The bus stop device 10 also transmits a location code, such as a bus stop number, to the passing bus 2. The bus stop device 10 then returns to state 1426.

According to this embodiment of the invention, the bus stop device 10 may include a button (not shown) that may be pressed by a waiting passenger. In response to receiving a button press, the bus stop device 10 may enter state 1430, where it updates the display 20. Also, the bus stop device 10 may verbally announce the bus ETA times utilizing a voice synthesizer (not shown) as known to those skilled in the art. In this manner, visually impaired passengers may be informed of the bus schedule. From state 1430, the bus stop device 10 returns to state 1426.

While at state 1426, the bus stop device 10 may receive a data packet from the central office 32. If the bus stop device 10 receives a data packet, the bus stop device will enter state 1432. At state 1432, the bus stop device 10 decodes the ETA and other information contained in the data packet. Once the data has been decoded, the bus stop device 10 will display the ETA and other information on the display. The bus stop device 10 then returns to state 1426.

Referring now to FIGURE 14C, an illustrative state diagram 1450 describing the operation of a central office 32 will be described. According to this embodiment of the present invention, the central office 32 begins operation at state 1452, where data packs are assembled and transmitted to the bus stop devices 10. As described above, the data packets may include ETA information for untimely buses, and may also include other information such as weather, advertising, etc. Such advertisement, weather, and other information is queued at state 1456 for assembly into data packets at state 1452. If the central office 32 detects a bus 2 leaving the dispatch station, the central office 32 transmits the bus schedule to the bus at state 1454. Alternatively, a bus schedule transmission device containing the bus schedule may be placed

proximate to the dispatch station for transmitting the bus schedule to a passing bus 2. The central office 32 then returns to state 1452.

5 If, at state 1452, the central office 32 receives an untimeliness report message from a bus 2, the central office 32 enters state 1458. At state 1458, the central office 32 computes the ETA for bus 2 at downstream bus stops 6. The central office 32 then returns to state 1452 where the ETA information is assembled into data packets and transmitted to the appropriate downstream bus stop devices 10. In this manner, ETA information is only transmitted to downstream bus stop devices 10 for buses that are untimely.

10 In light of the above, it should be appreciated that the present invention provides a method and system for providing an ETA for a bus. While an actual embodiment of the invention has been illustrated and described, it will be appreciated that various changes can be made therein without departing from the spirit and scope of the invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A method for providing the estimated time of arrival for a bus, comprising:

- detecting a bus proximate to a first location;
- calculating the difference between a time said bus is detected proximate to said first location and an expected time of arrival for said bus at said first location;
- determining whether said difference exceeds a preset threshold;
- in response to determining that said difference exceeds a preset threshold, calculating an estimated arrival time for said bus at a second location; and
- displaying said estimated arrival time for said bus at said second location at said second location.

2. The method of Claim 1, wherein said first location comprises a first bus stop and wherein said second location comprises a second bus stop downstream from said first bus stop.

3. The method of Claim 1, wherein detecting a bus proximate to said first location comprises receiving a bus identification code from said bus as said bus moves proximate to said first location.

4. A system for providing the estimated time of arrival for a bus, comprising:

- a bus device located on said bus;
- a bus stop device operative to maintain an expected time of arrival for said bus;
- at least one downstream bus stop device comprising a display and located downstream from said bus stop device; and
- a central office;

and wherein said bus stop device is further operative to detect said bus as said bus moves proximate to said bus stop device, to determine whether the difference between a time said bus is detected proximate to said bus stop device and said expected time of arrival for said bus exceeds a preset threshold, and to transmit a notification message to said central office in response to determining that said difference exceeds said threshold;

and wherein said central office is operative to receive said notification message, to calculate an estimated arrival time for said bus at said downstream bus stop device in response to receiving said message, and to transmit said estimated arrival time to said downstream bus stop device;

and wherein said downstream bus stop device is operative to receive said estimated arrival time for said bus from said central office and to provide said estimated arrival time for said bus on said display.

5. The system of Claim 4, wherein said bus device is further operative to transmit a bus identification code that uniquely identifies said bus, and wherein said bus stop device is further operative to detect said bus as said bus moves proximate to said bus stop device by receiving said bus identification code.

6. The system of Claim 4, wherein said bus stop device further comprises a solar cell for providing electrical power to said bus stop device.

7. The system of Claim 4, wherein said bus stop device further comprises a transmitter capable of transmitting signals over a cellular network and wherein said bus stop device is further operative to transmit said notification message to said central office via a cellular network.

8. The system of Claim 7, wherein said downstream bus stop device further comprises a receiver capable of receiving signals over a cellular network and wherein said downstream bus stop device is further operative to receive said estimated arrival time for said bus via a cellular network.

9. The system of Claim 4, wherein said bus stop device further comprises a temperature control unit for controlling the temperature of said bus stop device.

10. An apparatus for providing the estimated time of arrival for a bus, comprising:

an intelligent transponder/receiver operative to detect a proximate bus and to determine whether the difference between a time said bus is detected and an expected time of arrival for said bus exceeds a preset threshold;

a transmitter/receiver operative to transmit a notification message to a central office if said difference exceeds said preset threshold and to receive an estimated time of arrival for a bus from said central office; and

a display operative to display said estimated arrival time for a bus.

11. The apparatus of Claim 10, wherein said transmitter/receiver is further operative to transmit said notification message and receive said estimated time of arrival over a cellular network.

12. The apparatus of Claim 11, further comprising a solar panel for providing electrical power to said transmitter/receiver, said intelligent transponder/receiver, and said display.

13. The apparatus of Claim 12, further comprising a temperature control unit for controlling the temperature of said transmitter/receiver, said intelligent transponder/receiver, and said display.

14. A method for providing the estimated time of arrival for a bus, comprising:

determining a location of a bus utilizing information received from global positioning system satellites;

transmitting said location to a central office;

calculating at said central office a difference between a time said bus arrives at said location and an expected time for said bus to arrive at said location;

determining at said central office whether said difference exceeds a preset threshold;

in response to determining that said difference exceeds said threshold, calculating at said central office an estimated time of arrival for said bus at a second location;

transmitting said estimated time of arrival for said bus at a second location to said second location; and

displaying said estimated time of arrival at said second location.

15. The method of Claim 14, wherein transmitting said estimated time of arrival for said bus at a second location to said second location comprises transmitting said estimated time of arrival for said bus at a second location to said second location via a cellular network.

16. The method of Claim 14, wherein transmitting said estimated time of arrival for said bus at a second location to said second location comprises

transmitting said estimated time of arrival for said bus at a second location to said second location via a communications satellite.

17. The method of Claim 14, further comprising transmitting said location to a bus stop device located at said location, and wherein transmitting said location to a central office comprises transmitting said location from said bus stop device to a central office.

18. A system for providing the estimated time of arrival for a bus, comprising:

a bus device located on said bus;

a bus stop device operative to display an expected time of arrival for said bus;

and

a central office;

and wherein said bus device is operative to determine a location of said bus and to transmit said location of said bus to said central office;

and wherein said central office is operative to receive said location of said bus, to determine whether the difference between a time said bus is detected at said location and an expected time of arrival of said bus at said location exceeds a preset threshold, to calculate an estimated arrival time for said bus at said downstream bus stop device in response to determining that said difference exceeds said threshold, and to transmit said estimated arrival time to said bus stop device;

and wherein said downstream bus stop device is operative to receive said estimated arrival time for said bus from said central office and to display said estimated arrival time for said bus.

19. The system of Claim 18, wherein said bus device is operative to determine a location of said bus by utilizing a global positioning system.

20. The system of Claim 18, wherein said bus device is operative to transmit said location of said bus to said central office using a cellular network.

21. The system of Claim 18, wherein said bus device is operative to transmit said location of said bus to said central office using a communications satellite.

22. The system of Claim 18, wherein said bus stop device further comprises a temperature control unit for controlling the temperature of said bus stop device.

23. A method for providing the estimated time of arrival for a bus, comprising:

- receiving a bus schedule at a bus device located within a bus;
- detecting a bus stop device located proximate to said bus;
- transmitting said bus schedule from said bus device to said bus stop device;
- transmitting a bus stop number from said bus stop device to said bus device;
- calculating at said bus device the difference between a time said bus detects said bus stop device and an expected time of arrival for said bus at said bus stop device identified in said bus schedule;
- determining whether said difference exceeds a preset threshold;
- transmitting a message from said bus device to a central office in response to determining that said difference exceeds said preset threshold;
- calculating at said central office an estimated arrival time for said bus at a downstream bus stop device;
- transmitting said estimated arrival time to said downstream bus stop device;
- and
- displaying said estimated arrival time at said downstream bus stop device.

24. The method of Claim 23, wherein said bus stop device is operative to display advertisement information.

25. The method of Claim 23, wherein said bus stop device is operative to display weather information.

26. The method of Claim 23, wherein said bus stop device is operative to display said bus schedule.

27. The method of Claim 23, wherein said bus stop device further comprises a temperature control unit for controlling the temperature of said bus stop device.

28. The method of Claim 23, wherein said bus device is operative to transmit said message to said central office via a cellular network.

29. The method of Claim 23, wherein said bus device is operative to transmit said message to said central office via a communications satellite.

30. A system for providing the estimated time of arrival for a bus, comprising:

- a bus device located on said bus;
- a bus stop device;
- a central office, and
- a downstream bus stop device; and wherein

said bus device is operative to receive a bus schedule, to detect a bus stop device located proximate to said bus, to transmit said bus schedule to said bus stop device, to receive a bus stop number from said bus device, to calculate the difference between a time said bus detects said bus stop device and an expected time of arrival for said bus at said bus stop device identified in said bus schedule, to determine whether said difference exceeds a preset threshold, and to transmit a message to said central office in response to determining that said difference exceeds said preset threshold, and wherein

said central office is operative to calculate an estimated arrival time for said bus at said downstream bus stop device and to transmit said estimated arrival time to said downstream bus stop device; and wherein

said bus stop device is operative to transmit a bus stop number said bus device, to receive said bus schedule, and to display said bus schedule; and wherein

said downstream bus stop device is operative to receive said estimated arrival time and to display said estimated arrival time.

31. The system of Claim 30, wherein said bus schedule comprises a weekday bus schedule.

32. The system of Claim 30, wherein said bus schedule comprises a Saturday bus schedule.

33. The system of Claim 30, wherein said bus schedule comprises a Sunday bus schedule.

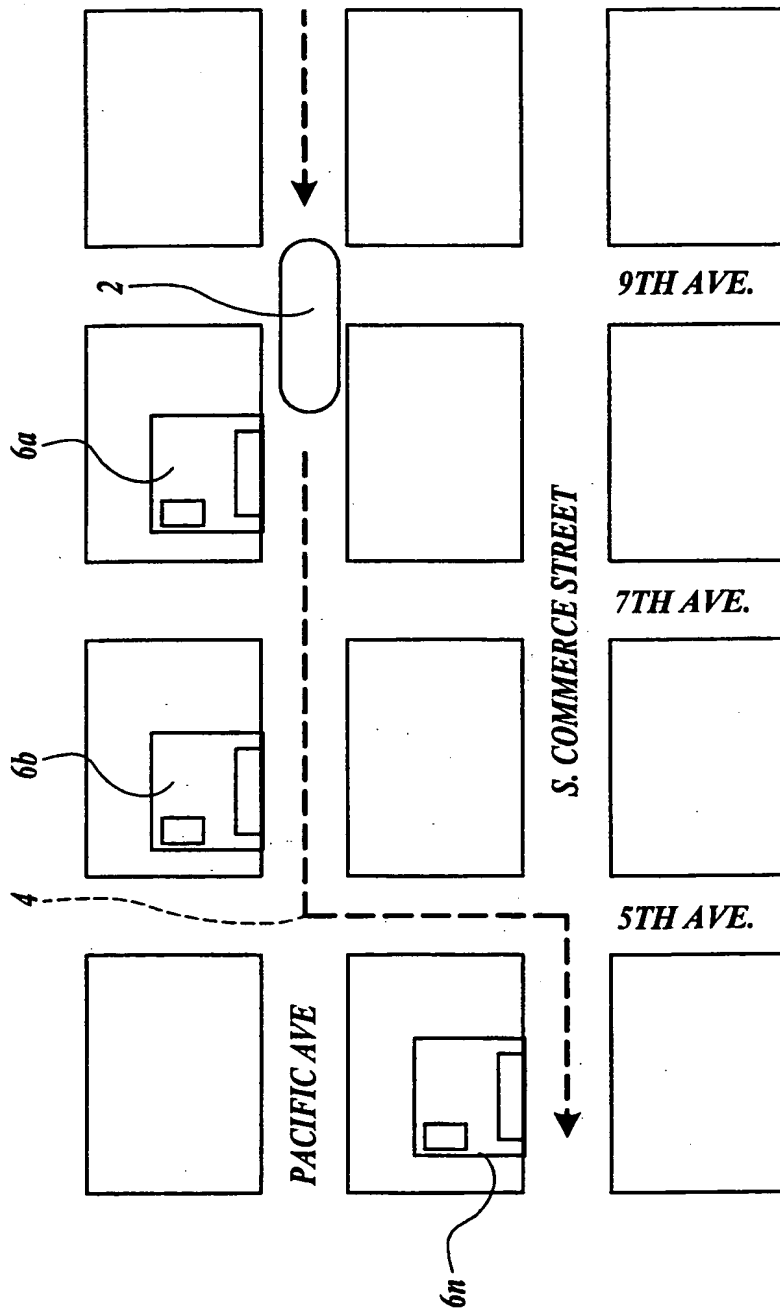
34. The system of Claim 30, wherein said bus device transmits said message to said central office via a cellular network.

35. The system of Claim 30, wherein said bus device transmits said message to said central office via a communications satellite.

36. The system of Claim 30, wherein said bus stop device further comprises a temperature control unit for controlling the temperature of said bus stop device.

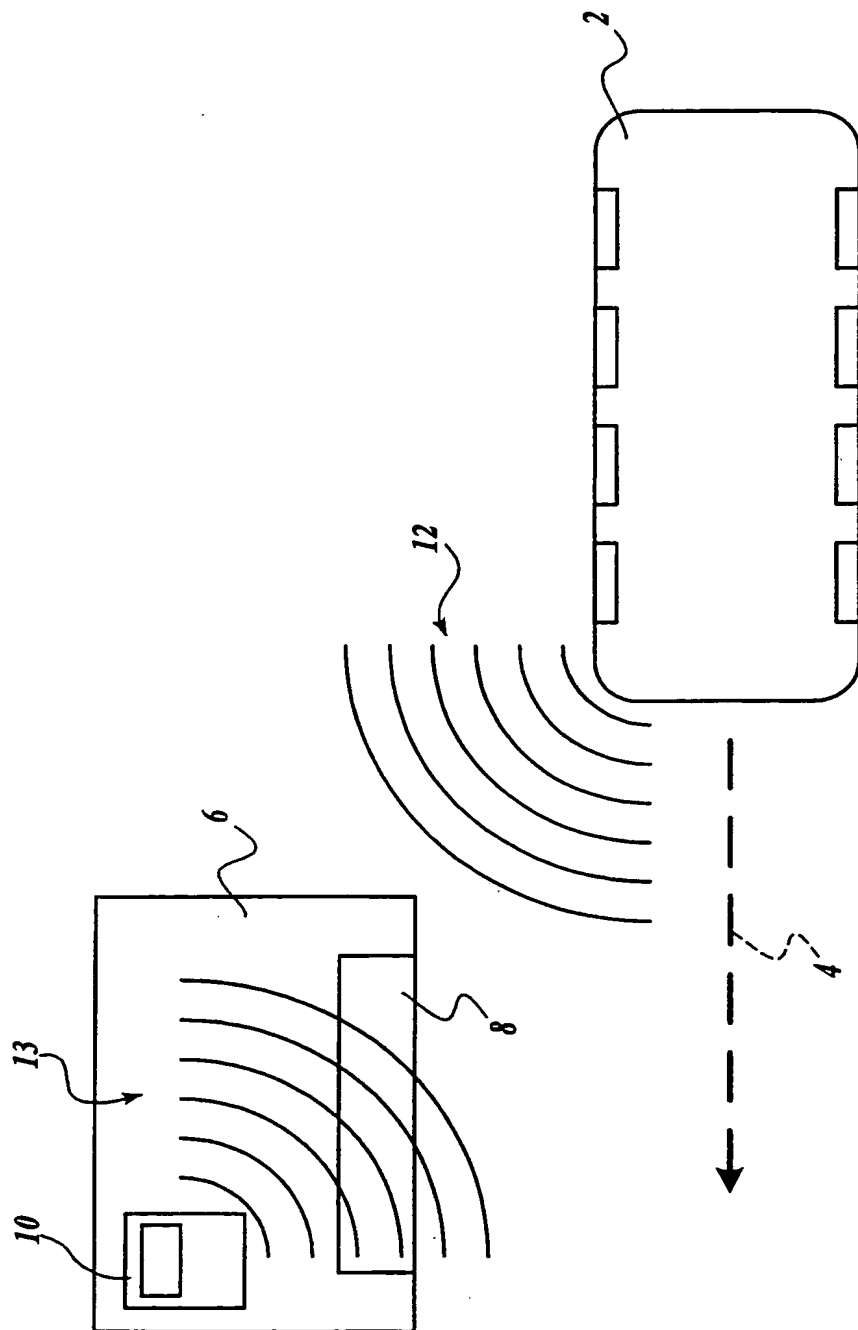
37. The system of Claim 30 wherein said bus stop device and said downstream bus stop device are addressed to receive broadcast messages from said central office.

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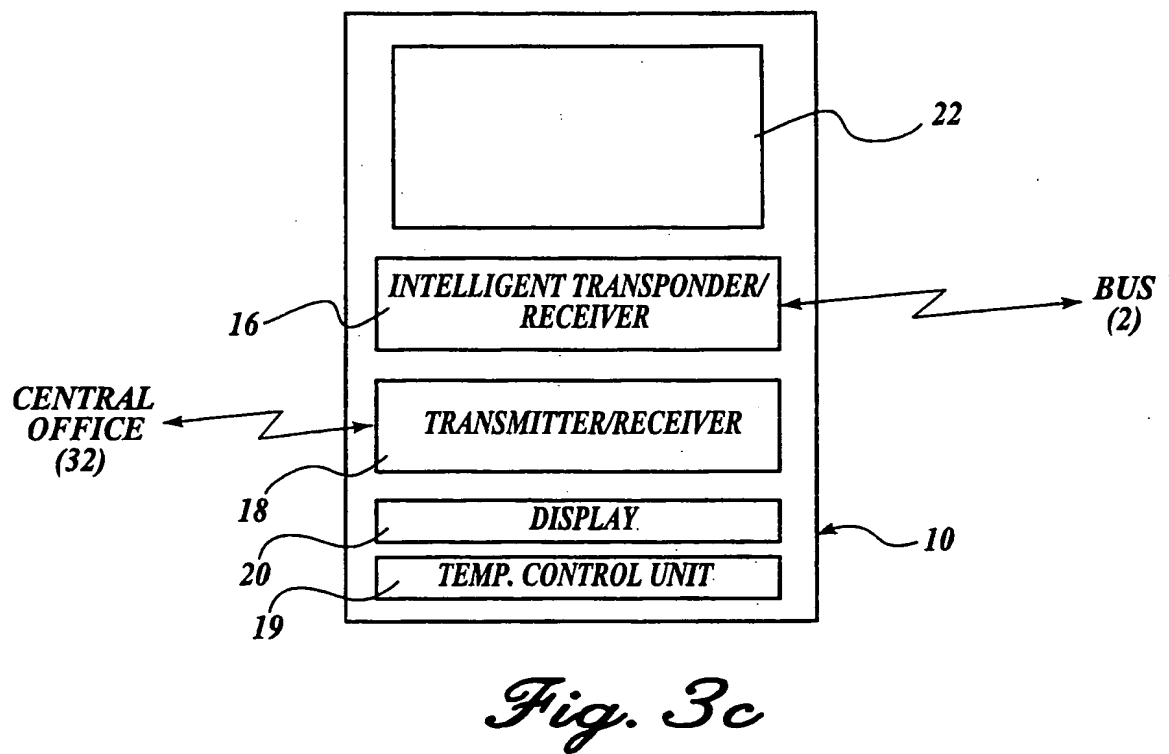
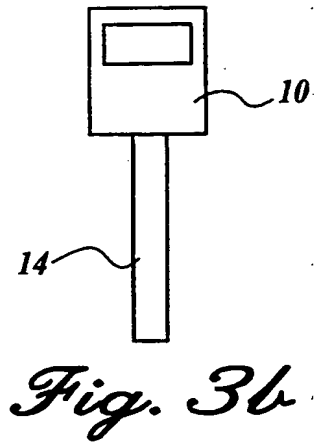
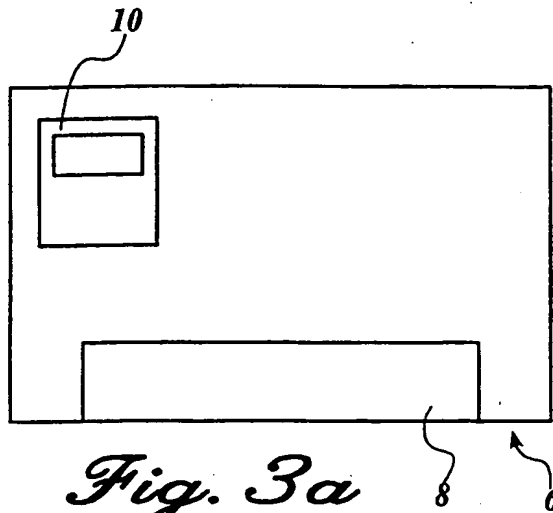
*Fig. 1*

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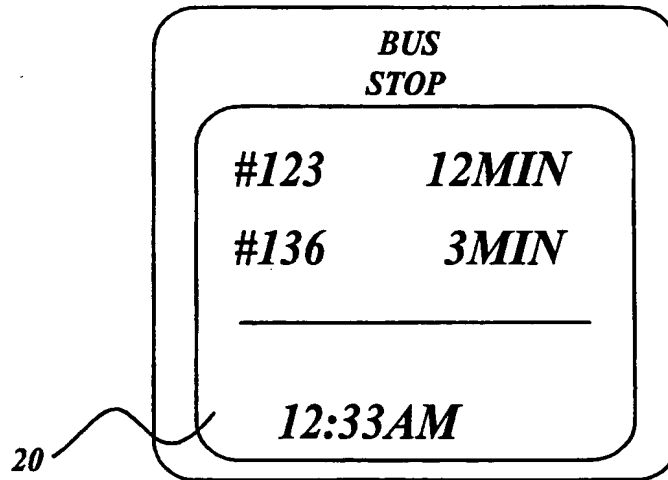
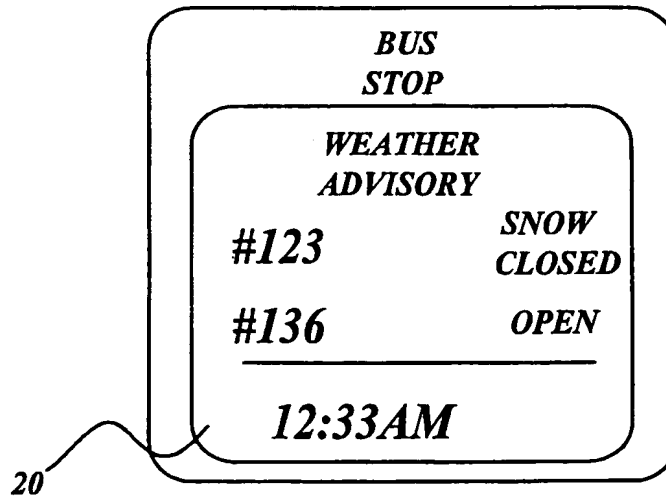


*Fig. 2*

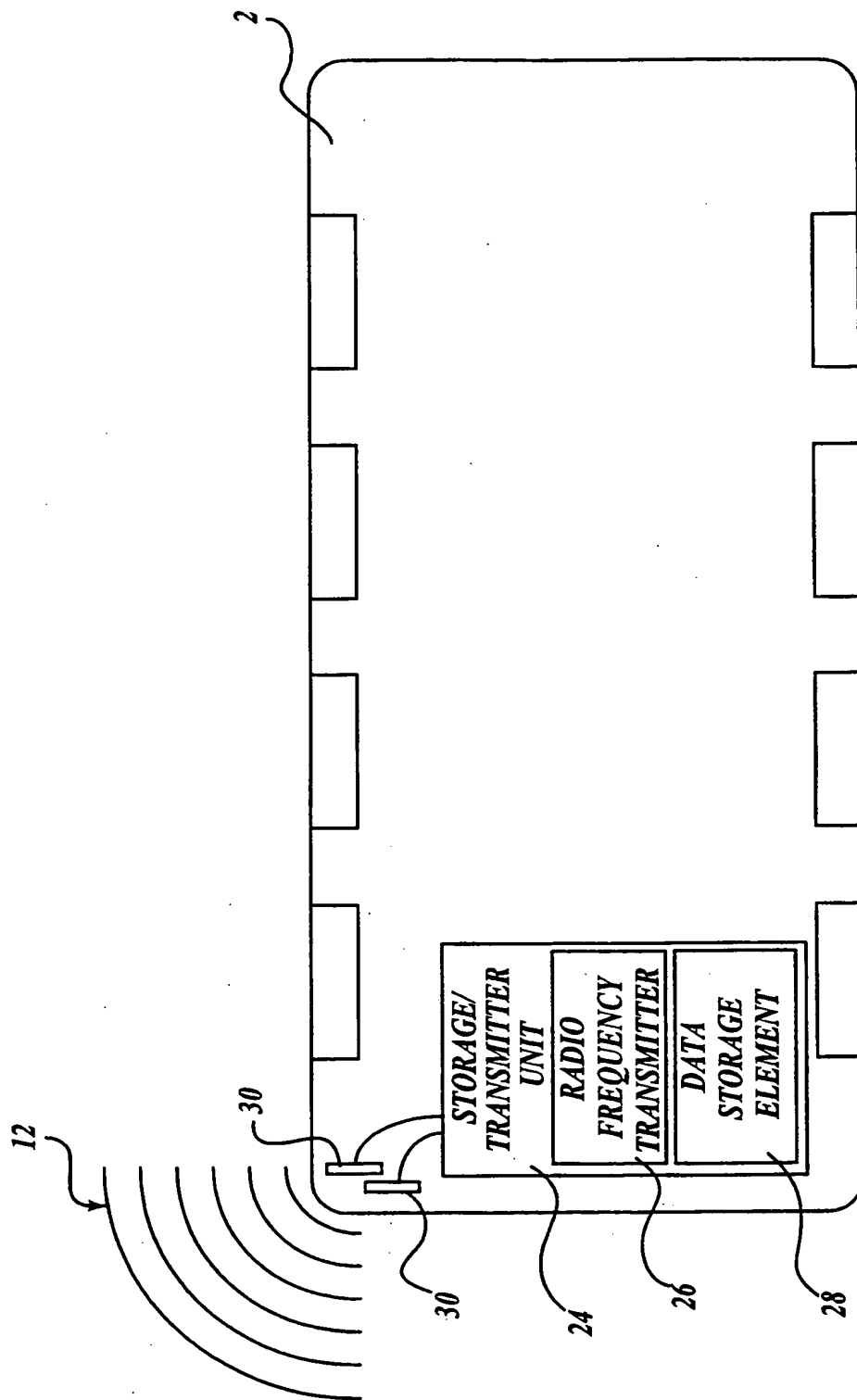
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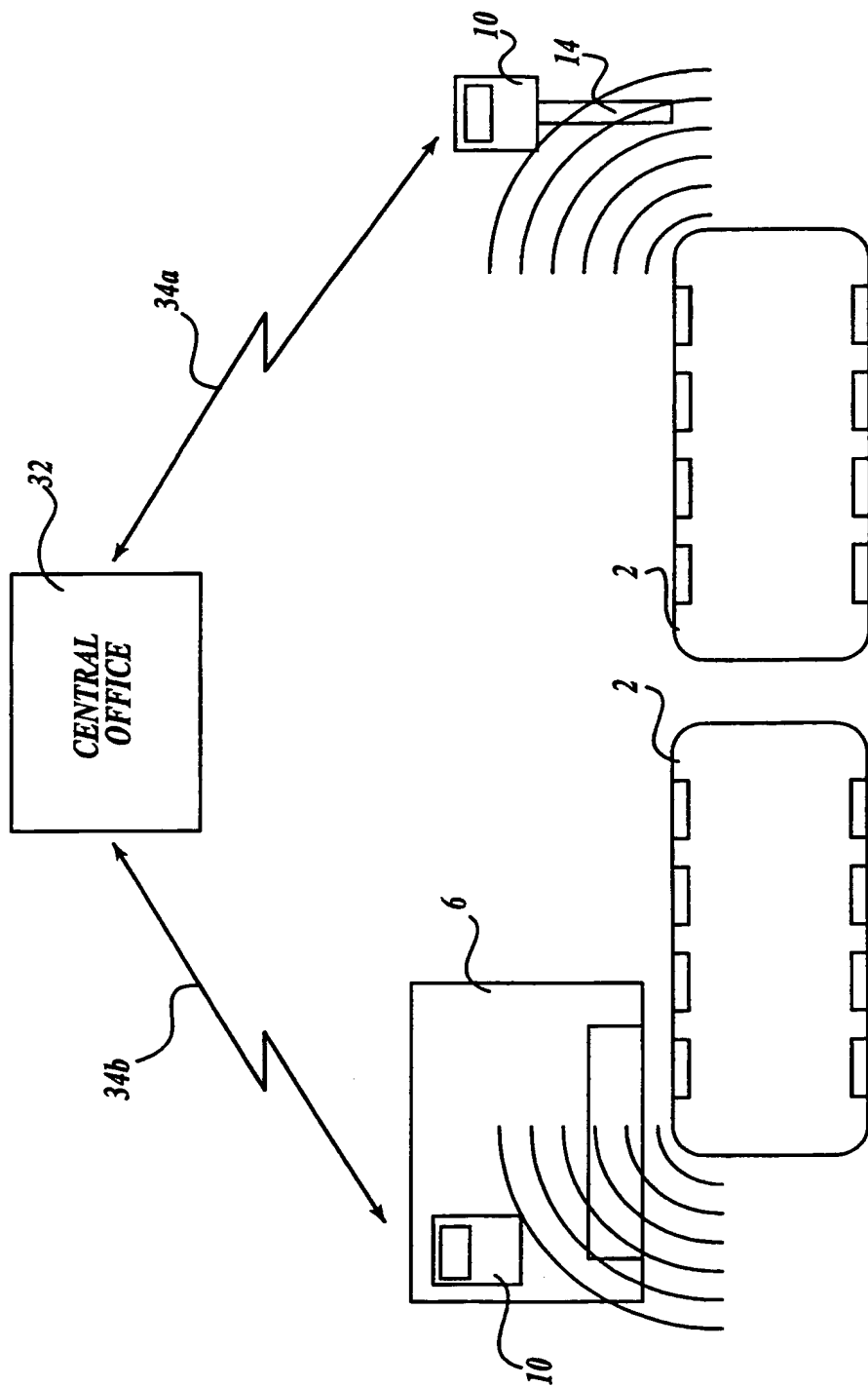
*Fig. 3d**Fig. 3e*

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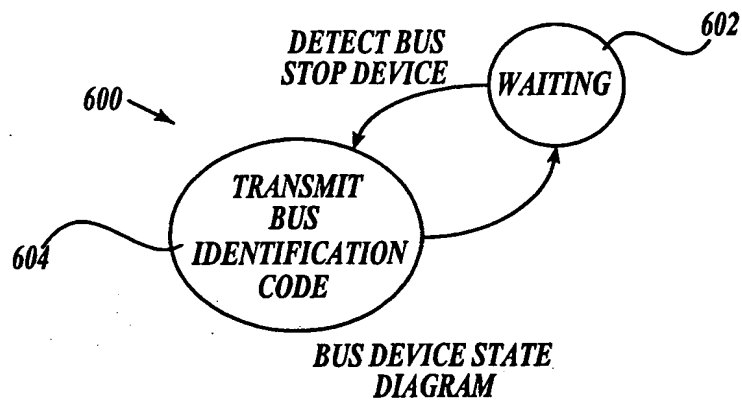
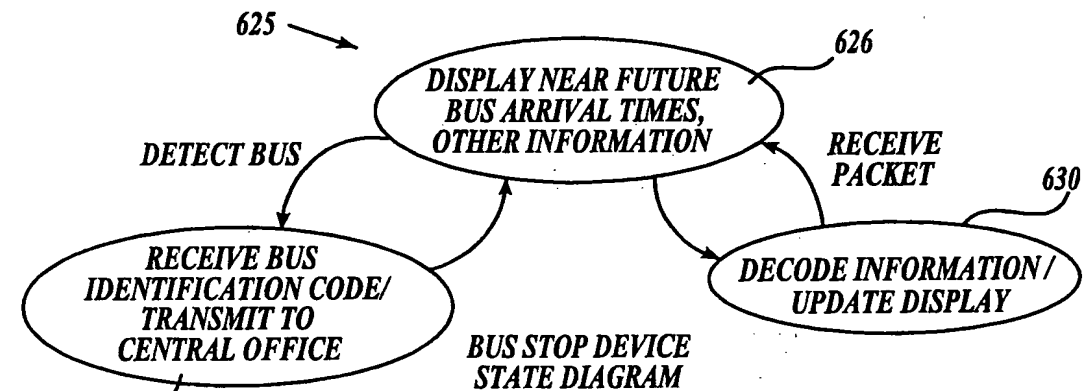
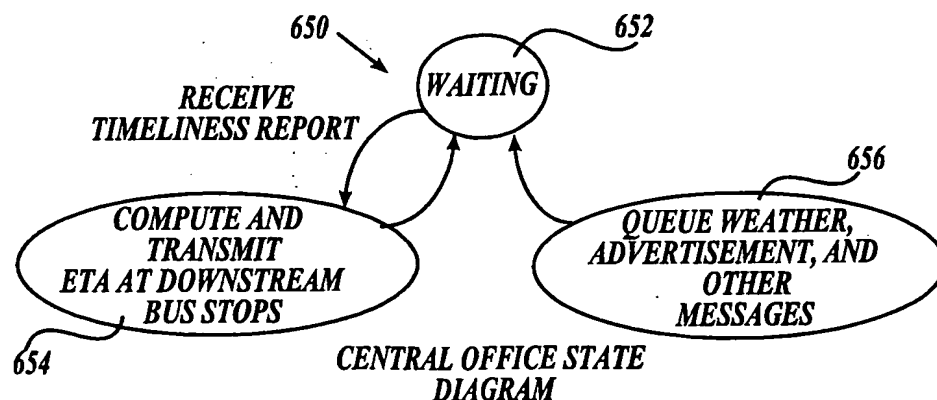
*Fig. 4*

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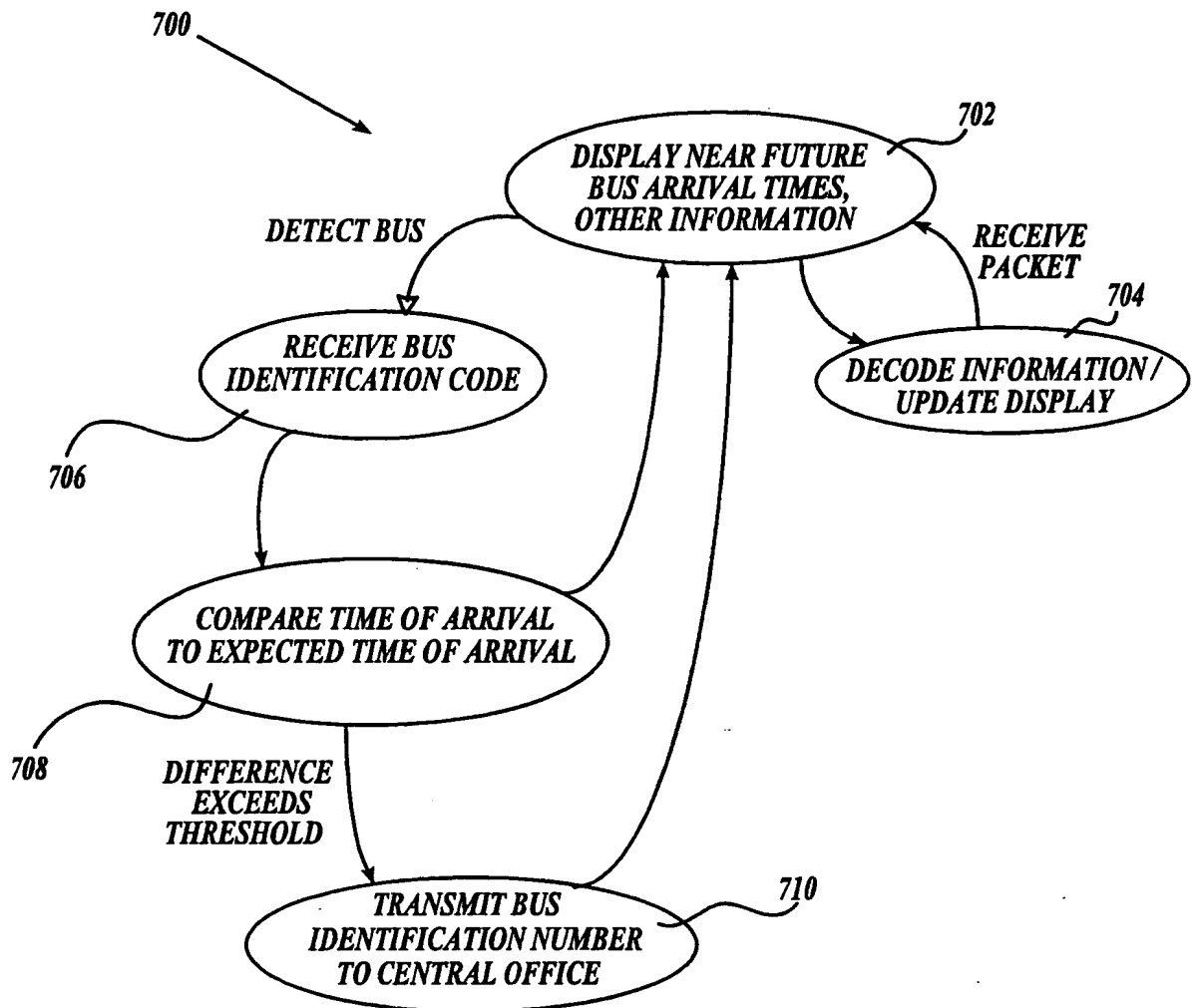


*Fig. 5*

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*Fig. 6a**Fig. 6b**Fig. 6c*

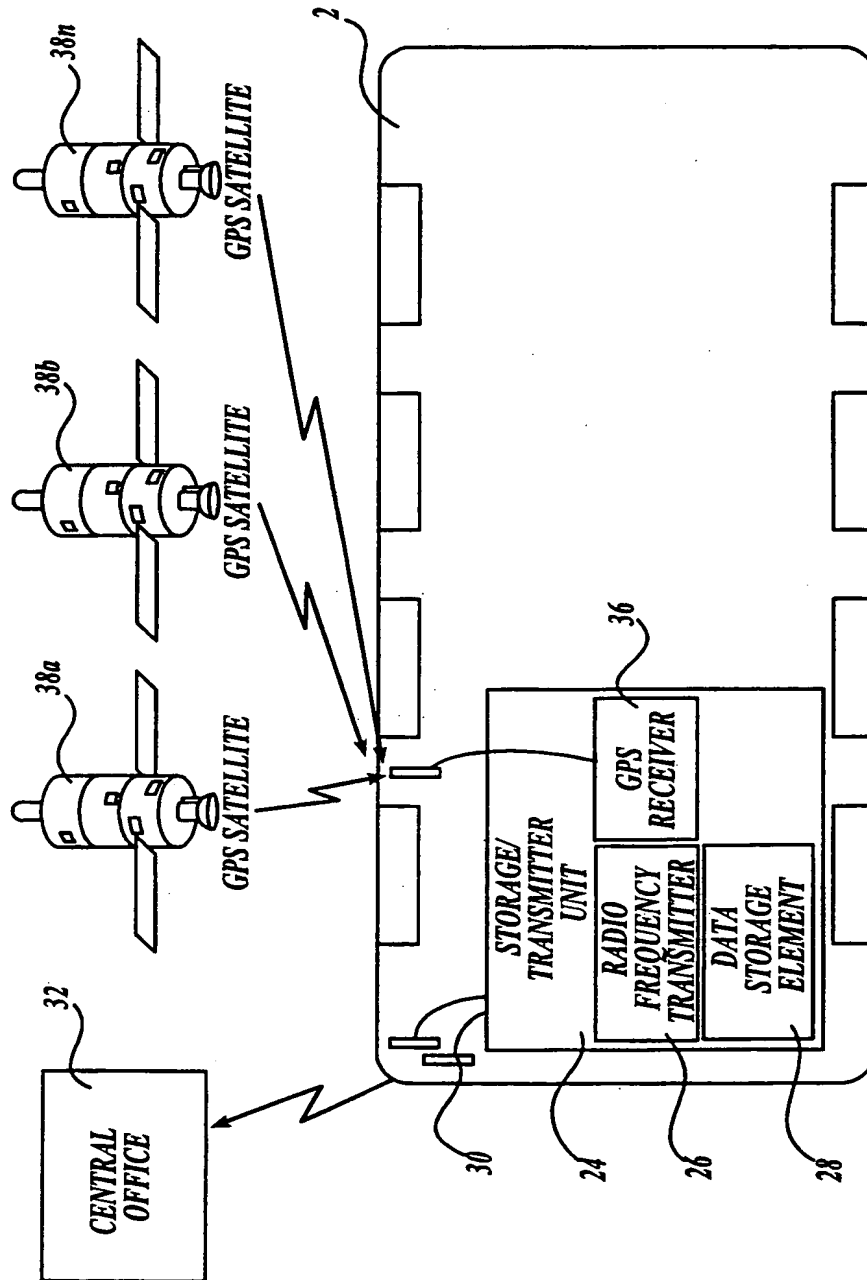
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### BUS STOP DEVICE STATE DIAGRAM

*Fig. 7*

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*Fig. 8*

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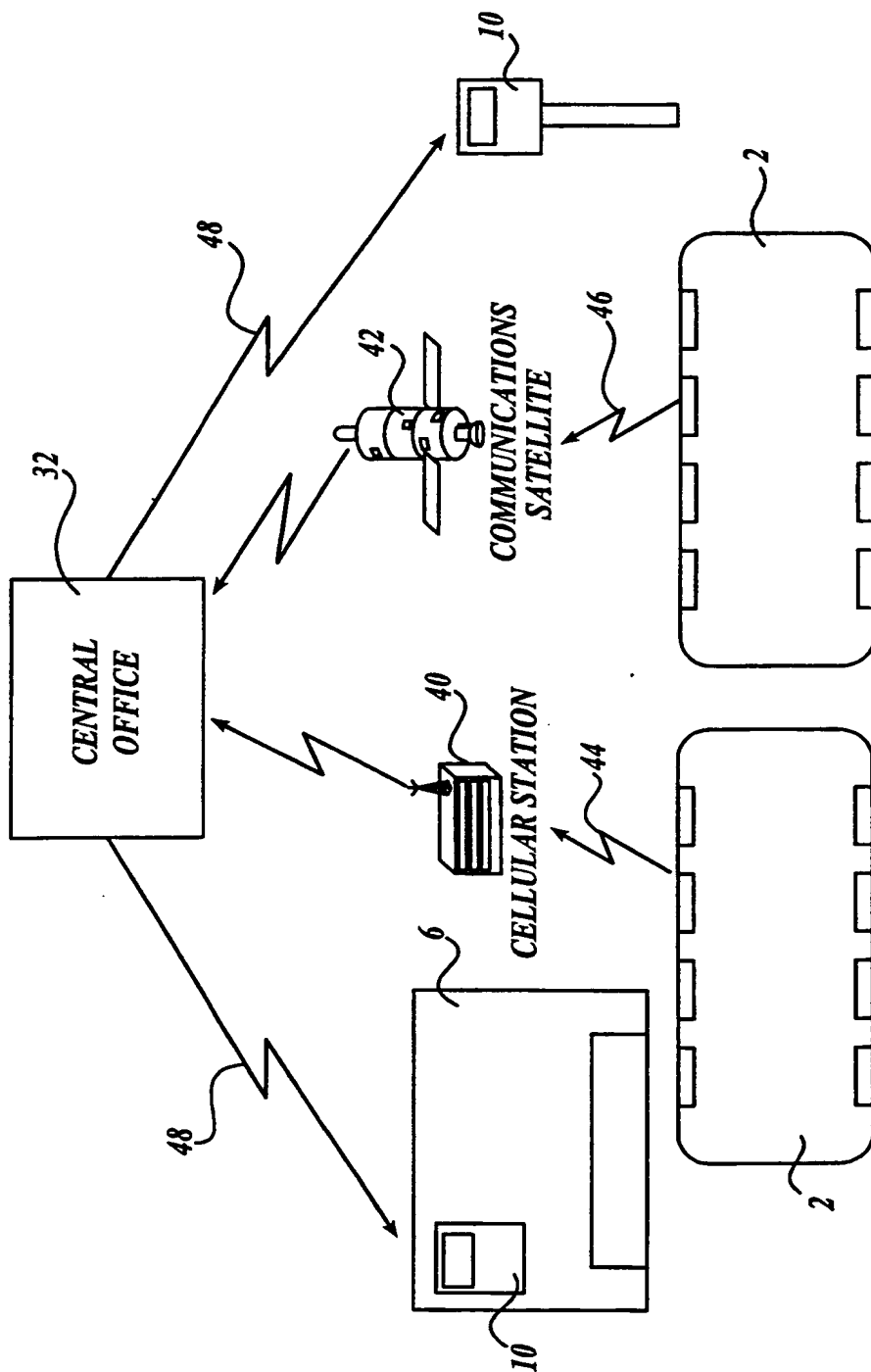
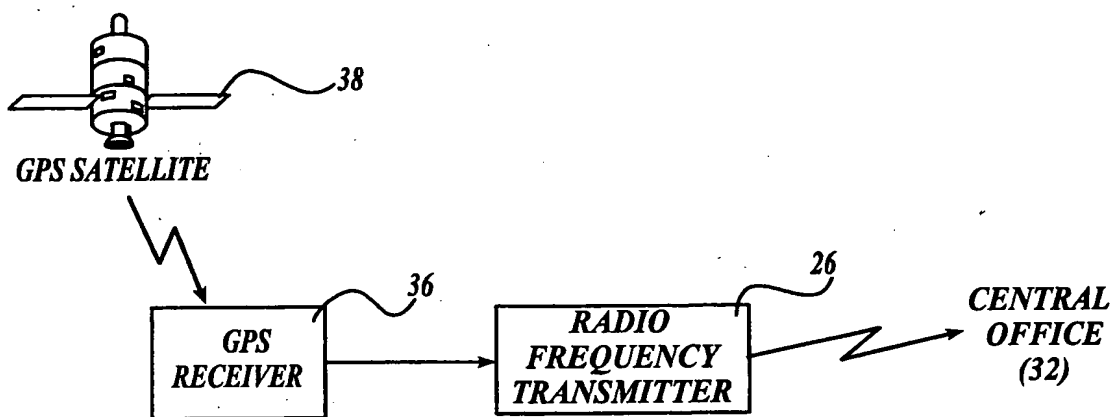
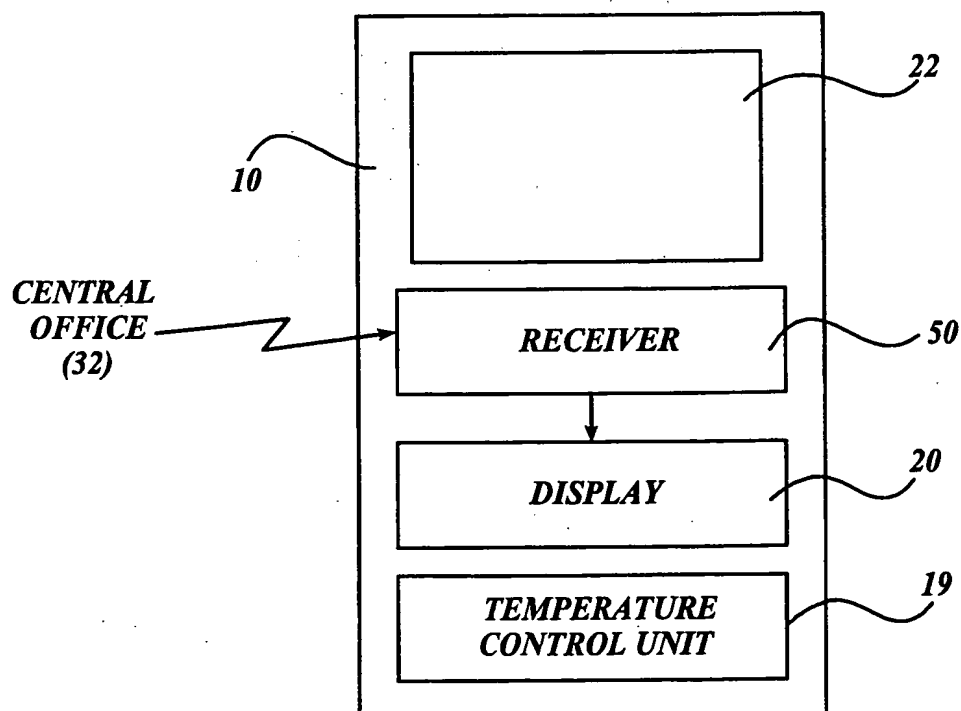
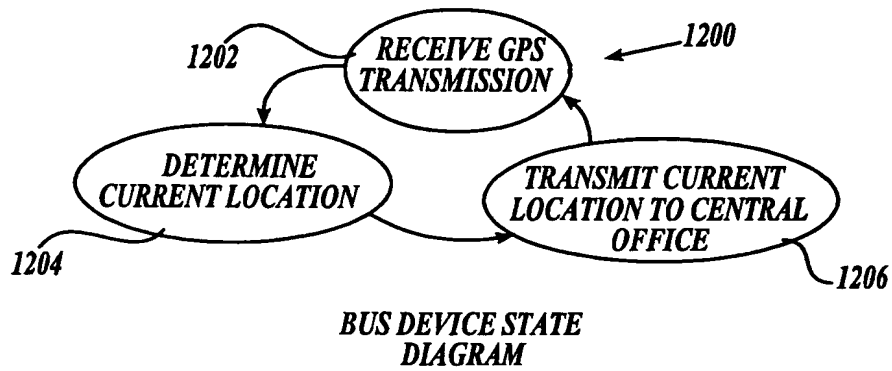
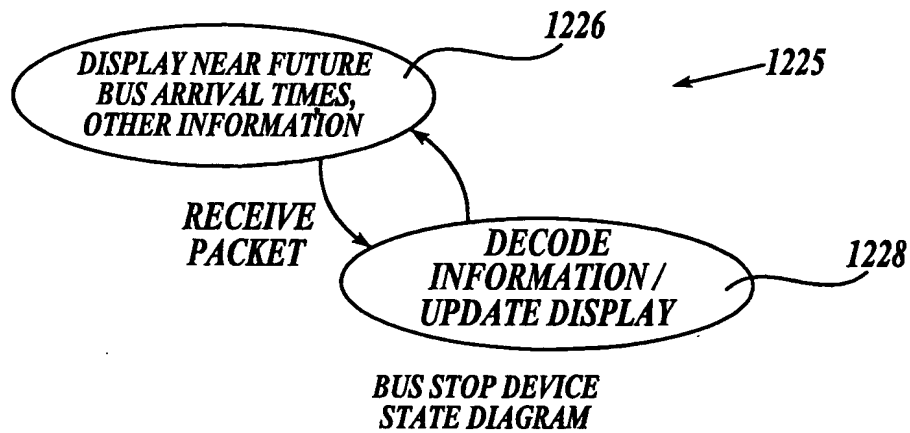
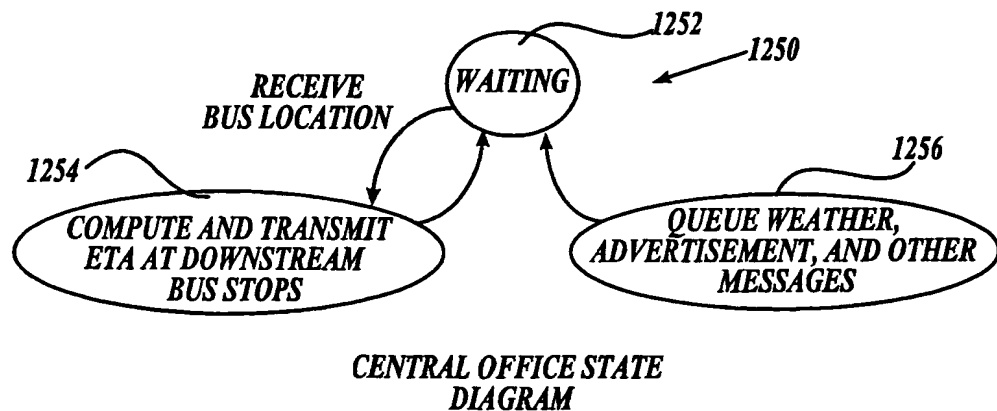


Fig. 9

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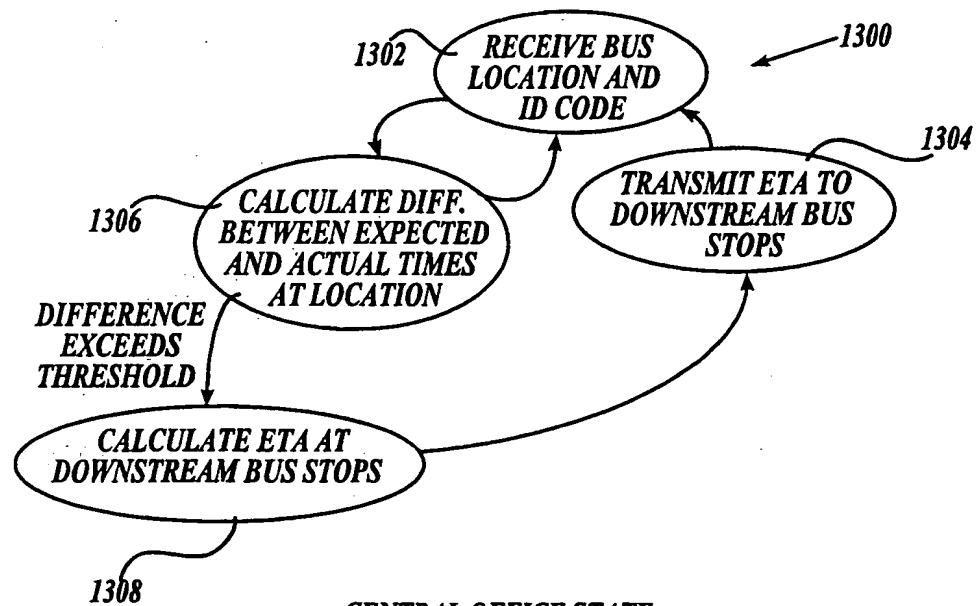
*Fig. 10**Fig. 11*

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*Fig. 12a**Fig. 12b**Fig. 12c*

SUBSTITUTE SHEET (RULE 26)

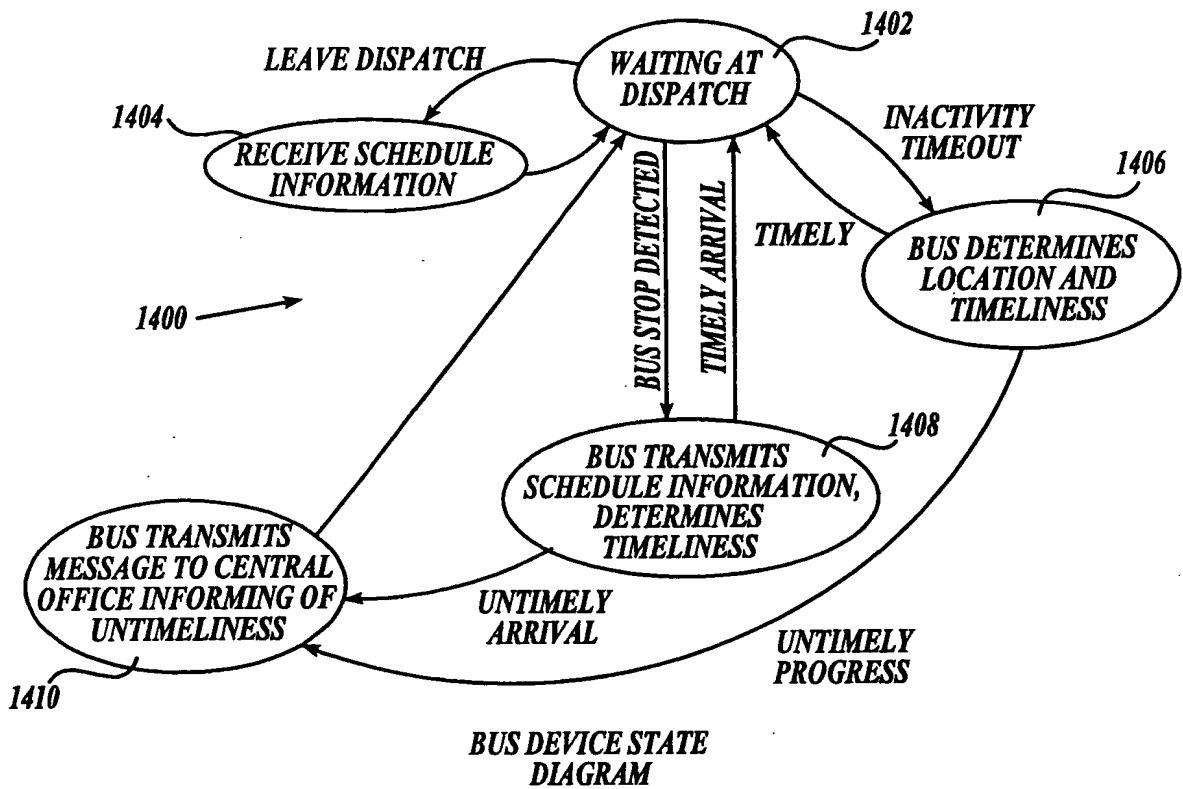
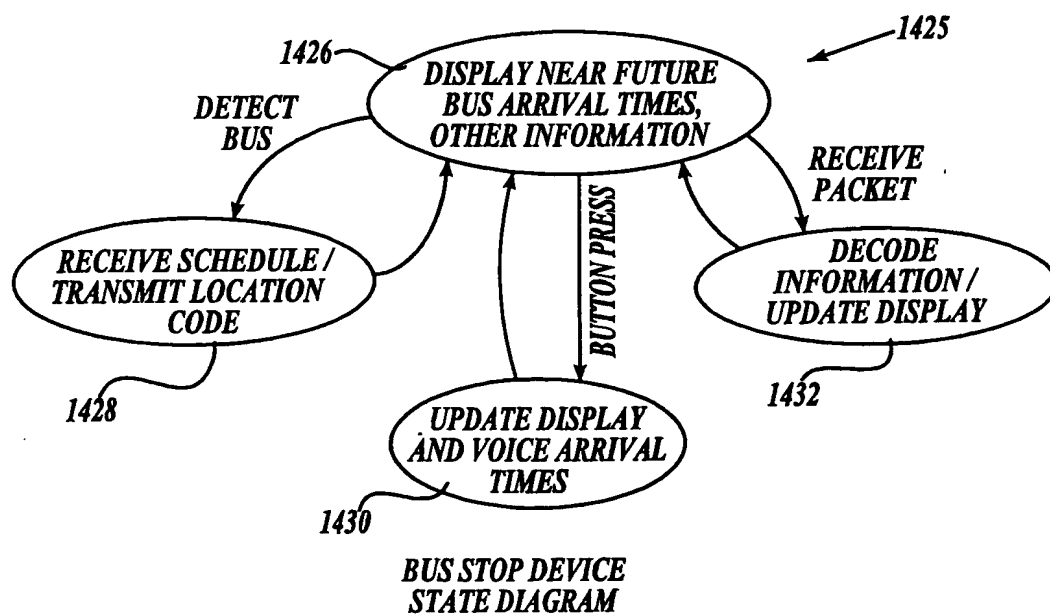
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CENTRAL OFFICE STATE  
DIAGRAM

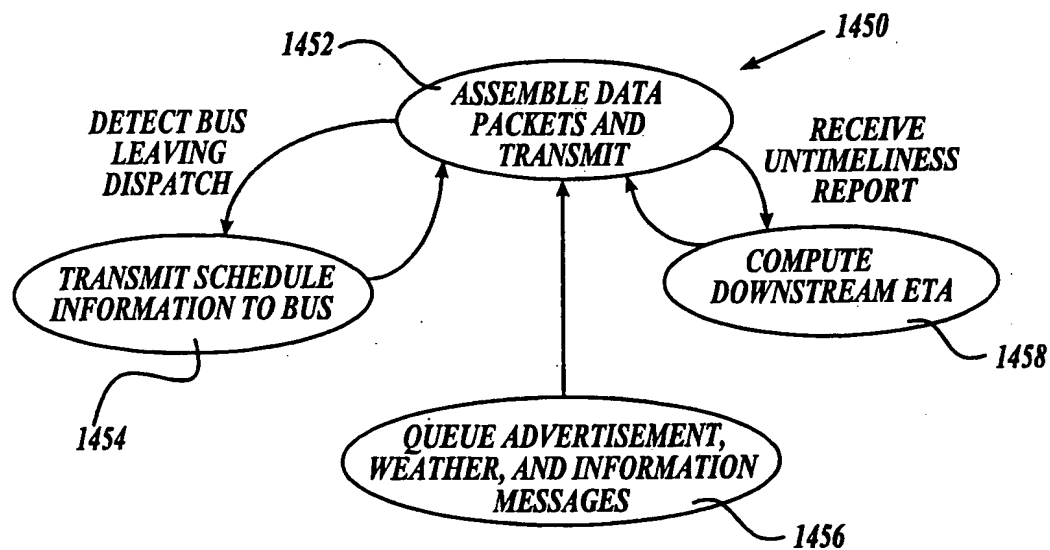
*Fig. 13*

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*Fig. 14a**Fig. 14b*

SUBSTITUTE SHEET (RULE 26)

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CENTRAL OFFICE STATE  
DIAGRAM

*Fig. 14c*

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 00/10343

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 7 G08G1/123

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 G08G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

WPI Data, EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 602 739 A (HAAGENSTAD JEFFREY D ET AL) 11 February 1997 (1997-02-11)  figure 11	1,4,10, 14,18, 23,30
A	US 5 724 243 A (KENNEDY III WILLIAM C ET AL) 3 March 1998 (1998-03-03)  column 4, line 18 - line 31	7,8,11, 15,20, 28,34
A	US 5 648 770 A (ROSS JOHN) 15 July 1997 (1997-07-15)	
A	US 4 799 162 A (SHINKAWA KIYOSHI ET AL) 17 January 1989 (1989-01-17)	
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☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

1 August 2000

Date of mailing of the international search report

08/08/2000

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### Information on patent family members

PCT/US 00/10343

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